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THE POTATO ASSOCIATION OF AMERICA

December 11 - 12 - 13, 1951

Netherland-Plaza Hotel

Cincinnati, Ohio

Joint meetings will be held with The American Phytopathological Society, December 11, and with The American Association of Economic Entomology, December 13.

Abstracts of papers for all sessions must be in the hands of Ora Smith, Secretary, by October 8.

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AMERICAN POTATO JOURNAL

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American Potato Journal

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RESPONSE OF THE POTATO TO FIELD APPLICATION OF MALEIC HYDRAZIDE*

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(Accepted for publication June 15, 1951)

INTRODUCTION

Since Schoene and Hoffman (5) first reported that maleic hydrazide inhibited growth of Bonny Best tomatoes, many lines of investigation have been initiated with this material on a large number of crop plants and weeds. Maleic hydrazide (MH) was first used for inhibition of sprouting of potatoes during the 1949-1950 storage season (3, 4). Results of further studies are presented here.

Tuberization in the potato has been increased by high concentrations of MH. Barnard and Warden (1) report a slight increase in tuberization from 0.1 per cent MH applied two weeks after emergence and accompanied by a slight reduction in size. When 0.5 per cent MH was applied, tuber set was further increased but a smaller percentage of the tubers attained No. 1 size. Many second growth and aerial tubers formed.

* Paper No. 341, Department of Vegetable Crops, Cornell University.

Denison (2) reported the effects of concentrations from 375 to 6000 ppm on the Kennebec variety when applied on July 6, July 20 and July 28, 1950. Yields of the early application showed a marked reduction increasing with concentration, while the second application gave a smaller yield reduction and the last application resulted in no significant reduction. Plants receiving the higher rates at the first application produced numerous small misshaped tubers. No difference was reported in the specific gravity of tubers from treatment or dates of application.

Wittwer and Sharma (6) stated that MH inhibited sprouting of onions in storage when applied at concentrations of 2500 ppm when one-third of the tops were down, one week before all tops were down. There was a significant reduction in sprouting accompanied by a reduction in storage rots five months after storage when 500 ppm had been applied. Bulbs from plants treated with 2500 ppm MH showed normal internal structure with no effect on flavor, color or odor. Bulbs were planted at the end of the five-month storage period and remained dormant and sound for eight weeks. A similar response was reported by these same workers for carrots.

Marshall and Smith (4) and Marshall (3) have reported effective sprout inhibition from 2500 ppm MH treatments to potato tubers when the material was injected into the tuber by sticking impregnated toothpicks in the tuber. Tubers immersed in a 2500 ppm solution of MH exhibited no control of sprouting. These data show that MH is not effective unless it enters the potato tissue.

Materials and Methods

Sebago potatoes planted on June 12, 1950 were used in this experiment. There were 3 replications, 4 application dates (July 21, August 4, August 18 and September 4), and 3 concentrations of MH in addition to a check plot which was not treated.

The MH was made up in concentrations of 0.001, 0.01 and 0.1 per cent of the pure material in water using the 30 per cent diethanolamine salt of MH.

On October 18, 1950, 10-hill samples of individual plants in each plot were harvested and observations made on the effect of MH on tuberization. Yield data also were taken.

Potatoes of 2-inch minimum size were held in common storage until November 27, 1950, at which time 15-tuber samples weighing between 2050 and 2171 grams each were placed in a 50°F. controlled temperature room. Observations on the loss of weight of each sample and the number of sprouts exceeding 1 cm. in length were made on January 25, 1951 and the samples replaced in storage. On March 30, 1951, all samples were removed from storage and the following data were taken: weight of

sample, number of sprouts more than 1 cm. in length, total number of buds producing sprouts or showing definite signs of growth and weight of sprouts over 1 cm. long.

Results

Foliage Response.

One week after the first spraying on July 21, there was no visible response to any treatment. Two weeks after the first spray, severe upward curling of the leaves of plants receiving 0.1 per cent MH was evident. Many small tubers were set close to the stems on very short stolons. There was no effect on flowering. The lower concentrations (0.01 and 0.001 per cent) showed no visible effect. Four weeks after the July 21 spraying, plants treated with 0.1 per cent MH still showed marked symptoms. By this time all the leaves were chlorotic, tightly curled upward, and the plants were stunted. Flowers were present on the unsprayed plants and on those which received lower concentrations, but they had either dropped off or were showing signs of abscission on the 0.1 per cent plots. On August 18, no injury had yet appeared in any of the plants treated on August 4.

Increase Tuberization from Use of MH

Table 1 shows the increase in tuberization per 10-hill plots as a result of time of application and concentration. Only tubers over one-half inch in diameter were counted but observations were made of those of smaller size. Figure 1 shows the increase in tuber number and swellings from a plant treated with 0.1 per cent MH obtained at random from the treated plot compared with a non-treated plant.

Table 1.—*Effect of date of application and concentration of MH on number of tubers per plant.*

Per cent MH	Date of Application				Ave. No. per Plant
	July 21	August 4	August 18	Sept. 4	
Untreated	9.70	6.77	5.83	6.50	7.20
0.001	7.70	6.90	5.97	6.30	6.72
0.01	7.87	6.97	5.73	6.30	6.72
0.1	11.20	8.53	6.93	6.03	8.18
Ave. No. per Plant	9.12	7.29	6.12	6.28	7.20

	Dates of Application	Conc. of MH	Dates x Conc.
LSD 5 per cent	0.79	0.79	1.58
LSD 1 per cent	1.06	1.06	2.13

The number of tubers per plant was increased significantly when MH was applied about the time of initial tuber set. At later dates of application, there was less increase in tuberization. Rain shortly after spraying on August 18 may account for the lower stimulation of tuberization on this date.

Decreased concentration of sprays and later applications resulted in fewer tubers per plant less than one-half inch in diameter. When 0.1 per cent MH was applied early, the largest increase in tuber-like swellings occurred. The 0.01 per cent and 0.001 per cent applications resulted in a slight increase in number of swellings at the first two dates of application, but no increase was noted from the later applications.

Table 2 shows the effect of dates of application and concentrations of MH on the average size of tubers over one-half inch in diameter. There was a significant reduction in average tuber size and an increase in number of tubers per plant. A highly significant reduction in size was obtained when MH was applied early as compared to later applications.

The 0.1 per cent MH application resulted in a highly significant reduction in average tuber size compared with 0.01 and 0.001 per cent MH and with untreated.

TABLE 2.—*Effect of date of application and concentration of MH on average tuber weight in grams.*

Per cent MH	Date of Application				Ave. Size per Conc.
	July 21	August 4	August 18	Sept. 4	
Untreated	148	163	191	215	179
0.001	168	187	190	212	189
0.01	159	173	177	202	178
0.1	69	103	163	214	137
Ave. Size per Date of Application	136	156	180	211	171

	Dates of Application	Conc. of MH	Dates x Conc.
LSD 5 per cent	24.9	24.9	51.24
LSD 1 per cent	33.6	33.6	——

Tuber Abnormalities Caused by MH.

Figure 2 shows the type of tuber injury resulting from early applications of a high concentration of MH. Figure 1 shows the tendency for treated plants to produce a large number of tubers with very short stolons.

The abnormally shaped tubers in Figure 2a appear to be similar to "second growth". Lateral swellings also appeared at nodes of the stolons where no growth is normally expected.

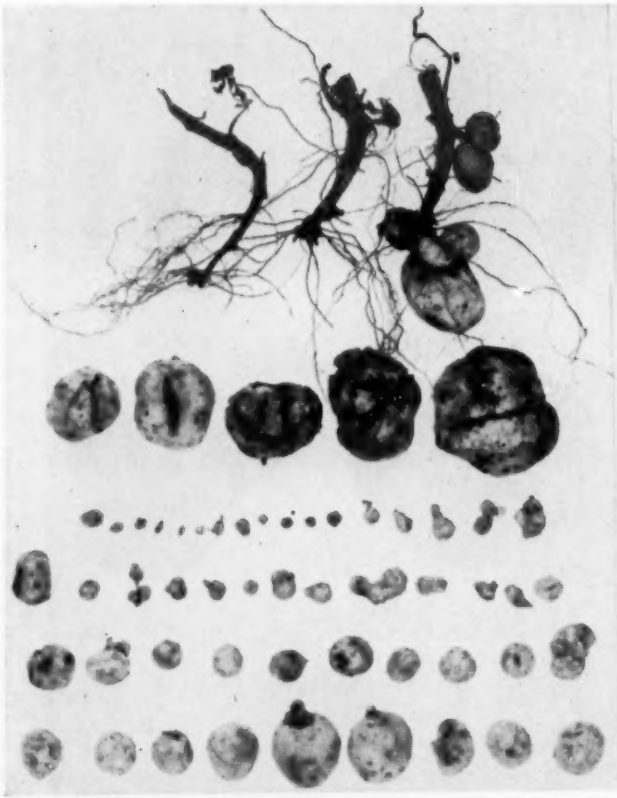

Fig. 1a—Increased tuber set from a plant treated with 0.1 per cent MH on July 21.

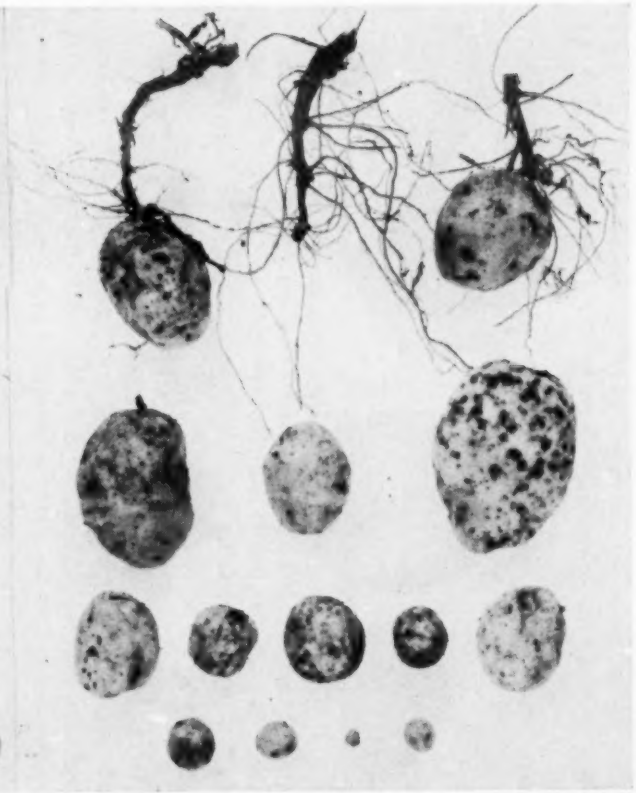

Fig. 1b—Tuber set from a similar adjacent untreated plant.

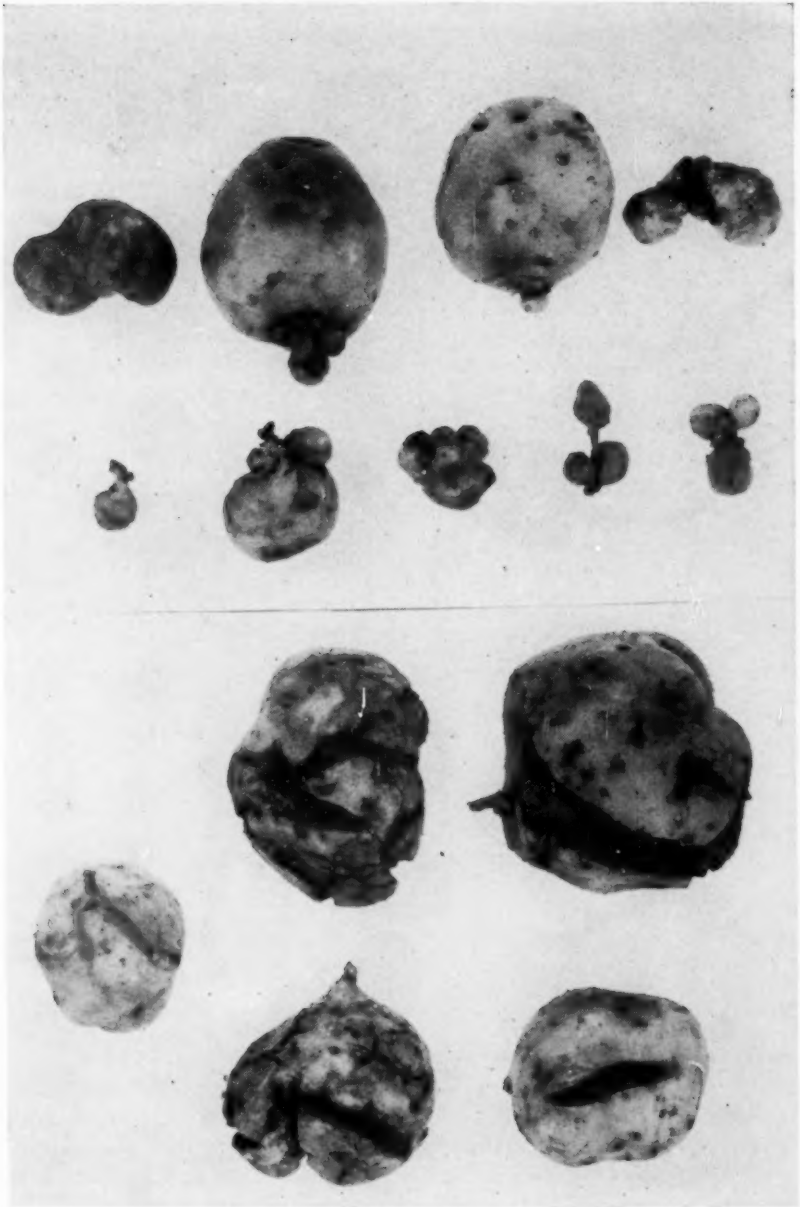

Fig. 2a—Abnormal growths on tubers from plants treated with 0.1 per cent MH on July 21.
2b—Injury similar to "growth cracks" on larger tubers from same plant.

Figure 2b shows the type of injury caused on the larger tubers from use of 0.1 per cent MH early in the season. The large cracks appear to be similar to "growth cracks".

In general, the only plants showing abnormal tuber developments were those treated with 0.1 per cent MH on July 21 or August 4, or 0.01 per cent MH on July 21.

Yields.

Applications of MH did not cause a significant reduction in total yields nor in yields of tubers above 1⅞ inches in diameter. However, injury was so great in plots receiving 0.1 per cent MH on July 21 and August 4, that no marketable potatoes were obtained.

The yield of potatoes below 1⅞ inches in diameter was significantly increased by use of 0.1 per cent MH on July 21 and August 4 and was decreased significantly by the September 4 application.

Effect of MH on Tubers Placed in Storage.

Table 3 shows the response of tubers in storage to application of MH at different dates in the field. The last date of application resulted in a highly significant reduction in per cent total weight lost in storage and per cent loss other than sprouts compared with the first date of application. Rain several hours after application on August 18 probably caused the small sprout retardation in storage from that application.

There was no difference between dates of application in per cent weight loss of sprouts. Application on the last date reduced the number of sprouts over 1 cm. long on January 25, 1951.

MH increased the number of active eyes per tuber when applied late in the season. However, at the end of the storage season, there was no significant difference in the number of sprouts over 1 cm. long.

The effect of the concentrations of MH on storage losses is shown in table 4. The 0.1 per cent MH concentration caused a highly significant reduction in per cent total weight loss, per cent weight loss other than sprouts and per cent weight loss of sprouts when compared with the other concentrations used. The 0.001 per cent MH concentration resulted in increase in per cent loss other than sprouts and per cent total weight loss that was significantly greater than the check.

A highly significant reduction in the number of sprouts over 1 cm. long, three months after storage, was noticed with the 0.1 per cent MH treatment. After five months of storage, there was no significant difference in the number of sprouts over 1 cm. long. However, as shown in figure 3, the length of sprouts varies greatly and this is shown in per cent of weight lost from sprouts.

TABLE 3.—*Effect of dates of application of MH to plant foliage on response of tubers in storage.*

Date of Application		Per cent Wt. Loss Other Than Sprouts	Per cent Wt. Loss of Sprouts	Per cent Total Wt. Loss in Storage	No. Active Eyes per Tuber	No. Sprouts* over 1 Cm. Long — Jan. 25, 1951	No. Sprouts* over 1 Cm. Long — March 30, 1951
July 21	MH	7.89	5.65	13.54	4.5	34.8	47.9
	Untreated	8.29	5.98	14.28	3.9	37.0	38.3
August 4	MH	6.80	4.50	11.30	6.8	38.3	58.5
	Untreated	7.64	5.50	13.14	5.8	47.3	57.7
August 18	MH	7.47	5.67	13.14	6.4	39.7	66.1
	Untreated	7.74	5.96	13.70	5.4	35.3	52.0
Sept. 4	MH	6.62	4.49	11.11	7.3	29.7	48.4
	Untreated	7.48	7.16	14.64	5.6	36.7	48.0
Averages							
	MH	7.20	5.08	12.28	6.3	35.6	55.2
	Untreated	7.79	6.15	13.94	5.1	39.1	49.0
	Exp.	7.34	5.34	12.69	6.0	36.7	53.7
LSD 5 Per cent		0.61	—	1.27	0.78	5.34	—
LSD 1 Per cent		0.83	—	1.71	1.05	7.21	—

*Figures represent total per 15-tuber storage sample.

TABLE 4.—*Effect of concentrations of MH on storage behavior of tubers from field sprayed plants.*

Concentration Used	Per cent Wt. Loss Other Than Sprouts	Per cent Wt. Loss of Sprouts	Per cent Total Wt. Loss in Storage	No. Active Eyes per Tuber	No. Sprouts* over 1 Cm. Long — Jan. 25, 1951	No. Sprouts* over 1 Cm. Long — March 30, 1951
Untreated	7.79	6.15	13.94	5.1	39.1	49.0
0.001 per cent	8.28	6.96	15.24	5.5	42.2	55.3
0.01 per cent	7.36	5.62	12.98	5.9	42.0	63.0
0.1 per cent	5.94	2.65	8.59	7.4	23.4	47.3
Average	7.34	5.34	12.69	6.0	36.7	53.7
LSD 5 per cent	0.61	2.82	1.27	0.78	5.34	—
LSD 1 per cent	0.83	—	1.71	1.05	7.21	—

*Figures represent total per "-tuber storage sample.

Figure 3a shows that 0.1 per cent MH not only causes small sprouts in those eyes showing activity, but also shows the breaking of apical dominance with this concentration. A concentration of 0.01 per cent MH, while causing a slight reduction in sprout length, did not overcome apical dominance to any great extent. Figure 3b shows the sprout inhibition caused by the earlier applications of 0.1 per cent MH. The treatment 10 weeks before harvest (August 4) was more effective in reducing sprouting and breaking apical dominance than the treatment made eight weeks before harvest (August 18). Figure 3c compares the effect of dates of application of 0.1 per cent MH. Effective control of sprouting was obtained by spraying as early as August 4, but the injury to plants and tubers was high at this date. Increased sprouting from the treatment made eight weeks before harvest is probably due to rain shortly after the treatment was applied.

From table 5 the effect of increasing concentration on decreased storage loss is noted when combined with later application dates. The later applications of higher concentrations of MH cause an increase in the number of active eyes, but do not show any difference in the number of sprouts over 1 cm. long.

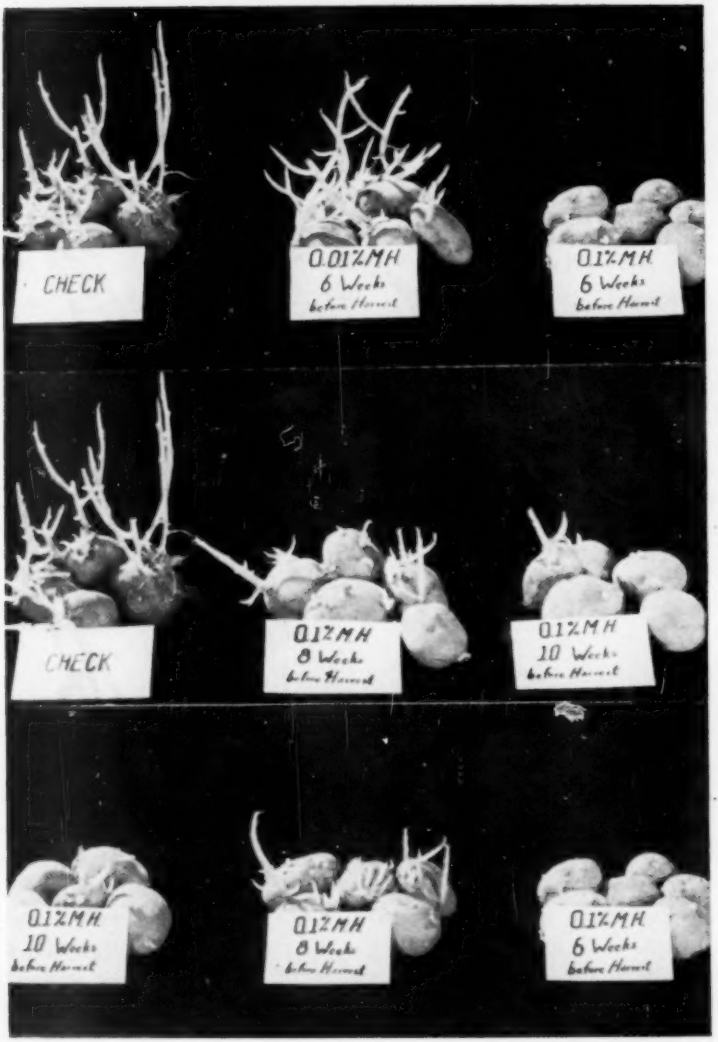

Fig. 3a—Effect of 0.01 per cent and 0.1 per cent MH on retardation of sprouting in storage.

3b—Effect of 0.1 per cent MH applied 8 and 10 weeks before harvest on retardation of sprouting in storage.

3c—Effect of date of application of 0.1 per cent MH on retardation of sprouting in storage. Rain received shortly after the 8 weeks-before-harvest treatment may account for the increased sprout growth shown.

TABLE 5.—*Effect of dates of application and various concentrations of MH on storage behavior of field sprayed potatoes.*

Date of Application	Per cent MH	Per cent Wt. Loss Other Than Sprouts	Per cent Wt. Loss of Sprouts	Per cent Total Wt. Loss in Storage	No. Active Eyes per Tuber	No. Sprouts* over 1 Cm. Long — Jan. 25, 1951	No. Sprouts* over 1 Cm. Long — March 30, 1951
July 21	Untreated	8.29	5.98	14.28	3.9	37.0	38.3
	0.001	8.44	5.94	14.38	4.7	33.3	48.7
	0.01	8.14	6.15	14.28	4.3	36.3	44.0
	0.1	7.09	4.86	11.95	4.5	34.7	51.0
August 4	Untreated	7.64	5.50	13.14	5.8	47.3	57.7
	0.001	8.09	6.83	14.92	5.5	48.3	55.7
	0.01	7.05	5.46	12.51	7.0	50.0	78.0
	0.1	5.25	1.20	6.45	8.1	16.7	41.7
August 18	Untreated	7.74	5.96	13.70	5.4	35.3	52.0
	0.001	8.58	7.35	15.93	5.9	44.3	60.7
	0.01	7.69	5.72	13.40	6.1	39.0	65.7
	0.1	6.15	3.93	10.08	7.3	35.7	72.0
Sept. 4	Untreated	7.48	7.16	14.64	5.4	36.7	48.0
	0.001	8.01	7.72	15.72	5.9	43.0	56.3
	0.01	6.59	5.16	11.75	6.2	39.3	64.3
	0.1	5.26	0.59	5.85	9.7	6.7	24.7
	Average	7.34	5.34	12.69	6.0	36.7	53.7
	LSD 5 per cent	—	—	2.54	1.6	10.69	—
	LSD 1 per cent	—	—	—	—	14.41	—

*Figures represent total per 15-tuber storage sample.

Summary and Conclusions

1. Three concentrations of MH (0.1, 0.01 and 0.001 per cent) were applied to Sebago potatoes at four dates during the growing season and compared with untreated potatoes.
2. A concentration of 0.1 per cent MH applied about the time of initial tuber set caused a arge increase in the number of tubers formed, severe injury to forming tubers and curling and chlorosis of foliage accompanied with stunting of growth.
3. Foliage and tuber injury decreased with later applications and with less concentrated applications of MH.
4. High concentration of MH (0.1 per cent) caused a reduction in weight loss of sprouts, also an increase in the number of eyes showing activity.
5. In general, a high concentration of MH applied early in the growing season caused plant injury, but applied late resulted in a reduction in amount of sprouting in storage.

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A METHOD OF INDEXING POTATOES FOR VIRUS X BY USE OF PETIOLE OR TUBER JUICE[1]

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(Accepted for publication, June 10, 1951)

During the maintenance of a foundation potato seed program it may be necessary to index large quantities of potato seed to determine whether the tubers are free of virus X and other viruses. Since virus X does not cause recognizable symptoms in most varieties of potatoes, it is necessary to use some method of detecting potatoes infected with this virus. Heretofore, it has been the practice to inoculate indicator plants with the juice from potato foliage. The indicators most commonly used have been *Capsicum frutescens (C. annuum), Datura stramonium* and *Nicotiana tabacum*. Although use of such plants is recognized as the standard procedure, it is time consuming and may require considerable greenhouse space.

There are indications from the researches of some investigators that tubers might be used as a source of virus X in indexing. Johnson (8) was the first to report the use of tuber juice as a method of testing potatoes for this virus. The extracts he obtained by straining the scrapings of freshly cut tubers through cheese cloth were used to inoculate tobacco. Although the 63 tubers he used were infected with virus X, only 38 per cent of the tobacco plants inoculated showed virus symptoms. He reported that the virus did not appear to be localized in the tuber.

Burnett and Jones (3) attempted to facilitate the testing of potatoes for virus X by inoculating tomatoes with the juice from macerated tuber tissue in combination with tobacco mosaic virus. Their results with macerated foliage tissue were more reliable and they concluded that it was not practical to use macerated tuber tissue in testing potatoes for the presence of virus X.

The juice from macerated whole tubers was used by van der Meer (11) for rubbing the leaf surface of *C. frutescens, D. stramonium*, tobacco, tomato and other less common indicator plants, but he did not indicate how satisfactory the method was.

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[1] Publication approved by Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture; the North Dakota Agricultural Experiment Station; and the North Dakota State Seed Department.

[2] Agent (Plant Pathologist), Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture; Plant Pathologist, North Dakota State Seed Department; and Associate Plant Pathologist, North Dakota Agricultural Experiment Station.

In serological tests conducted by Gratia and Manil (6), the anti-X-virus serum produced flocculation in juice from tubers infected with virus X. Judging by the relative facility of flocculation, their results showed that the virus was more plentiful in the outer portion of the tuber. In a test conducted with 87 Erdgold tubers infected with virus X, David and Stormer (5) found that a 1:1 dilution of the juice from the pulverized vascular bundles of each tuber gave a positive reaction when rubbed on the leaves of *C. frutescens*. A method whereby the tuber was used as a source of inoculum and as an instrument for inoculation was developed by Bald and White (1). A tuber was drawn over a piece of coarse sandpaper to break the skin and the exposed surface rubbed on the carborundum-dusted leaves of 2 or 3 *D. stramonium* seedlings. In a series of experiments involving about 1,500 tubers, Bald and White reported that over 90 per cent of the tubers produced infection. Various degrees of symptom expressions occurred, but some infected plants did not produce symptoms. Serological tests were conducted by Clinch (4), using extracts obtained from the skin and flesh of virus-X-infected tubers and the areas surrounding and including the dormant buds. Contrary to the results of Gratia and Manil (6), none of Clinch's extracts flocculated with immune serum. From these results Clinch concluded that the quantity of virus X in dormant tubers was extremely small.

According to Bawden, Kassanis and Roberts (2) the virus X content of different parts of potato plants varies but is sufficiently high everywhere for successful transmission. When tests were made from dormant tubers, they found it was advisable to take inoculum from cortical tissues containing eyes rather than from storage parenchyma. No data were given to indicate how successful the tuber method was but they did report that *D. stramonium* was preferred to tobacco because it was more susceptible to infection. It was also indicated that a negative reaction in *D. stramonium* was no assurance that virus X was not present. In such instances the symptomless plants were inoculated with a strain of virus X known to cause symptoms in *D. stramonium* to determine whether cross protection existed. Although Roberts (10) did not mention the technique or indicate how satisfactory tubers were as a source of virus X, inoculum from sprouts or a cone-shaped piece of tuber bearing an eye was used to inoculate tobacco and *D. stramonium*. Using the globe amaranth, *Gomphrena globosa*, as the indicator plant, Wilkinson (12) determined the virus activity of various portions of Green Mountain tubers infected with virus X. He made extracts from the sprouts, skins, eyes, bases of buds, cortices, vascular rings and piths and reported the sprouts to have the highest virus content. In general, there was a gradual decline in virus activity from the outside to the center of the tuber.

The reports reviewed indicate that variable results have been obtained by the use of tuber juice as a source of virus X. It is possible that more consistent results would have been obtained if a better indicator plant had been available. Because *G. globosa* is very sensitive to infection by virus X, the possibility of using this indicator for developing a tuber juice method of indexing was investigated. Previous to using the tuber juice method, potato petioles were used as a source of virus X. The present investigation provided an opportunity to compare the reliability of the 2 indexing methods.

Experimental Procedures and Results

The practice of indexing certified potato seed for virus X was started at the North Dakota Agricultural Experiment Station in 1946. The original procedure was to use the petioles of greenhouse-grown plants to inoculate *C. frutescens* in the following manner. Forceps dipped in alcohol and flamed were used to remove approximately 1½ inches of a petiole from a potato plant. A sterilized putty knife was held in the other hand and used as a base for crushing one end of the petiole. The juice that was deposited on the putty knife was brushed to the surface of a carborundum-dusted pepper leaf with the crushed end of the petiole. No. 400 carborundum was applied to the pepper plants with a No. 119 DeVilbiss powder blower. The putty knife was used to support the pepper leaf while the surface of the latter was rubbed with the crushed petiole. In order to obtain an ample quantity of juice to wet the surface of the pepper leaves thoroughly, it was sometimes necessary to crush the end of the petiole two or three times. Previous to indexing, it was always advisable to maintain an abundant amount of soil moisture in the greenhouse bench where the potatoes were growing. After a pepper leaf was inoculated the putty knife and forceps were wiped with a cloth or paper towel, dipped in alcohol and flamed. In order that the instruments would not become too warm to hold comfortably, it was advisable to have 2 putty knives and 2 forceps. By using this indexing procedure it was not necessary to touch the pepper plants or the potato petioles with the hands.

Three thousand one hundred and forty-five pepper plants have been used for indexing Triumph, Cobbler and White Rose varieties of potato. Of this number, there were 98 instances when virus X symptoms were not observed on the peppers and duplicate inoculations were made on other peppers to determine whether escapes had occurred or certain potatoes were free of virus X. In most cases the second inoculations were positive, and the few potatoes that were thought to be free of

virus X gave positive tests when indexed on *G. globosa*. It is possible that some of the 98 peppers showing no typical virus X symptoms did have pimples (Fig. 1) on the stems, for this symptom was not recognized when the indexing started.

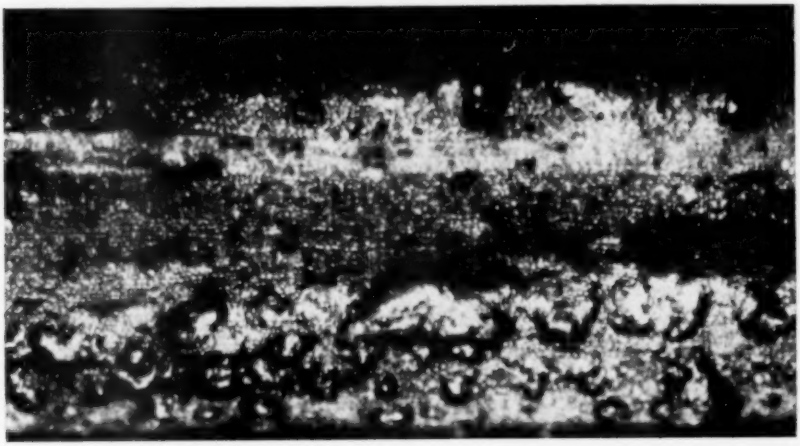

Fig. 1—Pimples on the stem of *Capsicum frutescens*.

Variation in the expression of virus X symptoms was noted among the few varieties of peppers originally used. There were also instances of variability within a variety. Because of this, 36 varieties were finally tested in an attempt to find one or more that would be satisfactory. Although some varieties expressed symptoms quicker and more consistently than others, no variety was found to be a dependable indicator of this virus.

Soon after Wilkinson and Blodgett (13) announced the use of *G. globosa* as an indicator for virus X, the author used it instead of *C. frutescens*. From 1948 to 1951, 5,135 potato petioles have been rubbed on a corresponding number of globe amaranth leaves, and there have been no indications that a virus-X-infected potato failed to produce the typical local lesions on this indicator. Wilkinson (12) gave some of the cultural characteristics of *G. globosa* and indicated the procedure used in making his inoculations. He reported that the young leaves were more susceptible to infection than the older ones. There may be a tendency to ignore this fact if a sufficient number of indicator plants are not available when a large number of potatoes are being indexed. Fewer lesions are produced on the older leaves and it is possible that escapes may occur.

Preliminary tests (7) of rubbing tuber juice on *G. globosa* indicated that this procedure might be a practical method of indexing tubers for the presence of virus X. The first test was conducted March 1, 1949, with

120 Pontiac tubers known to be infected with this virus. Within one week after the inoculations were made, all the globe amaranth leaves showed the typical local lesion symptoms of virus X. The procedure was somewhat similar to the petiole method given above. *G. globosa* leaves were numbered with India ink to correspond to the numbered tubers and No. 400 carborundum was applied to the leaves with a No. 119 De-Vilbiss powder blower. With the blade of a knife dipped in alcohol and flamed a piece approximately 1½ inches in diameter was cut from the stem end of a tuber. The stem end was used in preference to any other part so that the symptoms of any diseases that might be present in that portion of the tuber would be evident. Immediately after the tuber was cut a piece of paper toweling was held in one hand under the leaf in order to support the latter while it was rubbed with the cut surface of the tuber. The procedure and the equipment used are shown in figure 2. It is important that the leaf be rubbed as soon as the tuber is cut, because the tuber juice disappears as time elapses. The knife was wiped with a cloth or paper towel and sterilized before the next tuber was cut. A piece of new paper toweling was used for supporting each leaf. When certain lots of seed are being indexed by this method it may be necessary to grow

Fig. 2—Technique and equipment used for indexing potatoes for Virus X on *Gomphrena globosa* by the tuber juice method.

plants in the greenhouse so that they can be observed for other virus infections. In such cases an eye should be included in the piece that is cut from the tuber.

The tuber juice method was used to index additional Pontiac tubers known to be infected with virus X as well as certified Triumph and Cobbler seed. Green Mountain tubers infected with virus X were also included in the experiment. The results of indexing tubers of these 4 varieties are shown in table 1. Of the 3,770 tubers, 27 failed to produce symptoms on *G. globosa* the first time they were tested. When these 27 tubers were tested by this method a second time all but 2 Cobbler tubers gave positive tests for virus X. An eye from each of the 2 Cobbler tubers was planted and the petiole juice gave a positive test on globe amaranth.

TABLE 1.—*Results of indexing four varieties of potatoes on Gomphrena globosa by the tuber juice method.*

Variety	Number Tubers Tested	Number Tubers Negative
Pontiac	1991	6
Triumph	672	6
Cobbler	1006	15
Green Mountain	101	0

It is very probable that strains of virus X existed in the 3,770 tubers in table 1. In order to learn how reliable the tuber juice method was for testing tubers infected with mild virus X, a few Green Mountain tubers harboring mild virus X were obtained from E. S. Schultz of the Bureau of Plant Industry, Soils, and Agricultural Engineering. These few tubers were increased in 1949 and the increase was indexed in the greenhouse on *D. stramonium* by the petiole method. Three plants failed to produce any symptoms on *D. stramonium* but gave positive tests on *G. globosa*. The tubers from which these 3 plants were grown were increased in 1950 and the increase of 112 tubers tested on *G. globosa* by the tuber juice method in November. All but one tested positive and the negative tuber gave a positive reaction when tested by this method the second time.

In order to reaffirm that the Green Mountain tubers were carrying a mild strain of virus X, seed pieces from 66 of the 112 tubers were planted in the greenhouse during January 1951. In April, the petiole juice from each Green Mountain potato was used to inoculate 4 *D. stramonium* var. *tatula* plants. Only 8 of the 264 indicator plants showed symptoms of virus X. In 6 instances the symptoms were mild and a moderate reaction

occurred in the other 2 plants. The check plants inoculated with virus X from Triumph showed severe mottling and necrosis. Twenty of the symptomless *D. stramonium* var. *tatula* plants were picked at random for inoculation with virus X from Triumph. The failure of virus X symptoms to appear in these 20 plants indicated that cross protection was complete. The same Triumph virus X inoculum produced severe mottling in the check indicators.

The tuber juice method of indexing potatoes for virus X has certain advantages. It eliminates growing the plants and is thereby more rapid than using petiole juice. It saves the greenhouse space necessary for growing large quantities of potatoes. The greenhouse space can be used for *G. globosa*. A distinct advantage of this indicator is the fact that more than one potato can be indexed on the same plant. It also has the advantage of permitting test of tubers at any time during storage; the results of this experiment indicate that this is possible (Table 2).

TABLE 2.—*Results of tuber juice indexing of 3,770 Triumph, Cobbler, Pontiac and Green Mountain tubers during the storage months (October through May).*

Month	Number Tested	Number Negative
October	134	6
November	643	2
December	819	4
January	52	0
March	120	0
April	1628	15
May	374	0

Ladeburg, Larson and Walker (9) reported a delayed movement of virus X from the tubers into the aerial parts of some Chippewa and Sebago plants and stated that such instances make tests for the presence of virus X unreliable when based on sprouts or even young plants. The results of the present investigation with the varieties Triumph, Cobbler, Pontiac and Green Mountain indicated the petiole juice method was the most reliable. In the few instances where the tuber juice was negative, positive reactions were always obtained when the petiole juice was used.

Summary

1. A petiole juice method of indexing potatoes for virus X is described.
2. Thirty-six varieties of *Capsicum frutescens* were tested in an attempt to find one or more that would be a dependable indicator for virus X. Considerable variability in the expression of virus X symptoms existed within and between varieties. No variety was found to be a dependable indicator.
3. Of 3,145 pepper plants inoculated with the petiole juice of Triumph, Cobbler and White Rose potatoes, 98 failed to show typical virus X symptoms. Further tests indicated that the 98 tubers were infected.
4. Pimples on pepper stems were found to be a symptom of virus X and occurred concurrently with typical symptoms or during their absence.
5. Petioles from 5,135 potatoes have been rubbed on *Gomphrena globosa* leaves and there have been no indications that a virus-X-infected potato failed to produce the typical local lesions on this indicator plant.
6. A tuber juice method of indexing potatoes for virus X is described. The method may be used whenever the potatoes are in storage.
7. Of 3,770 virus-X-infected Pontiac, Triumph, Cobbler and Green Mountain tubers indexed on *G. globosa* by the tuber juice method, 27 failed to give a positive test the first time they were tested. Twenty-five of the 27 negative tubers gave a positive test the second time they were tested. The remaining 2 tubers were positive when tested on *G. globosa* by the petiole juice method.
8. One hundred and twelve Green Mountain tubers carrying a mild strain of virus X were indexed on *G. globosa* by the tuber juice method. All but one gave a positive test and a second tuber juice test of this one tuber was positive.
9. When 66 of the mild virus-X-infected Green Mountain potatoes were indexed on *Datura stramonium* var. *tatula* by the petiole method, only 3 per cent of the indicator plants showed virus X symptoms.
10. Although tuber juice indexing of mild virus X on *G. globosa* was a much more reliable method than rubbing mild X petiole juice on *D. stramonium* var. *tatula*, the results of this investigation indicated that the rubbing of petiole juice on *G. globosa* was the most dependable method.

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EFFECT OF SOIL REACTION ON THE PERFORMANCE OF CERTAIN SCAB-RESISTANT AND SUSCEPTIBLE POTATO VARIETIES (1)

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(Accepted for publication June 1, 1951)

On Long Island potatoes are grown every year on the same land, or are grown in a two-year rotation with other crops. Under these conditions potato scab is a serious problem where the soil reaction is not maintained at the proper level. To meet such problems, plant breeders have developed several scab resistant varieties and released them during the past few years (1), (2)*. The purpose of this paper is to discuss the results of four years' experiments in which certain scab-resistant and susceptible varieties were grown on soil reaction plots ranging in pH from 4.3 to 7.6.

Materials and Methods

In 1925 and 1928 soil reaction experiments were set up at the Long Island Vegetable Research Farm for a long range study of the effect

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* Numbers in parentheses refer to literature cited at end of paper.

of soil acidity on potatoes and other vegetables. The plan of these experiments was presented in considerable detail by Wessels in 1932 (3). The identical plots have been maintained through the present, and individual pH levels have not been changed markedly from the original. Various quantities of sulphuric acid and hydrated lime have been applied during the years to keep the pH of the various plots as near the selected point as possible.

Soil reaction ranged from pH 4.3 to 7.6 with gradations of 0.3 pH. The plots were arranged in two groups of five replications each, so that all ten replications could be put in one experiment, or they could be split into two experiments of five replications each. Only a twenty foot roadway separated the two groups of plots. Each plot consisted of four rows 34 inches apart and 38 feet in length. At least three guard rows separated the record rows of adjacent plots. Cultural practices were uniform for all the plots, so that variations in the soil reaction constituted the only experimental treatment under study. In 1947, 1948 and 1949 all ten replications were used, and in 1950 one group of five replications was planted to potatoes. A neutral 5-10-5 commercial fertilizer was applied at the rate of one ton per acre in 1947, 1948 and 1949, and at the rate of 2500 pounds per acre in 1950.

Each year the varieties under test were grown side by side across the soil reaction plots. In 1947 single rows of Ontario, Green Mountain, Irish Cobbler and Mohawk were tested. In 1948 Katahdin replaced Mohawk and the other varieties were the same as in 1947. Four test rows of Ontario were grown on each plot in 1949 and no other variety was planted that year. The 1950 experiment was designed to compare two scab-resistant varieties, Ontario and Yampa.

The potatoes were graded all four years on a hand operated grader, which had a chain with openings 1⅞ inches in diameter. Only yields of U. S. 1 size potatoes will be considered in this paper. In 1947 and 1948 careful inspection was made of all the tubers to separate the scabby ones from those that were scab-free. So little scab was found on Ontario, and this always mild infection, that sorting for scab was discontinued in 1949 and 1950 when only the scab-resistant varieties, Ontario and Yampa, were grown.

Results

1947: Yields of scab-free tubers for the four varieties are shown graphically in figure 1. Green Mountain and Irish Cobbler produced their highest yields of clean tubers between pH 4.3 and 5.2, falling off rapidly as the soil pH increased above 5.2. Mohawk yielded significantly more clean tubers below pH 5.5 than at pH 5.8 and above. All three scab-susceptible

varieties declined in yield with increasing pH until yields of less than 25 bushels per acre of scab-free tubers were produced at pH 7.6. On the other hand, Ontario yielded better at high pH levels than at extremely low pH, as can be seen in figure 1. Scab was not a problem on Ontario at any of the pH readings.

Figure 2 shows the performance of the susceptible varieties when scabby tubers were combined with clean tubers to give total yields. Although scab infection was severe on Green Mountain, Irish Cobbler and Mohawk above pH 5.2 and 5.5, scab had little or no effect on total yield. Since Ontario yielded nearly 100 per cent clean tubers throughout the pH range, the Ontario total yield curve is very similar to the curve for yield of clean tubers in figure 1.

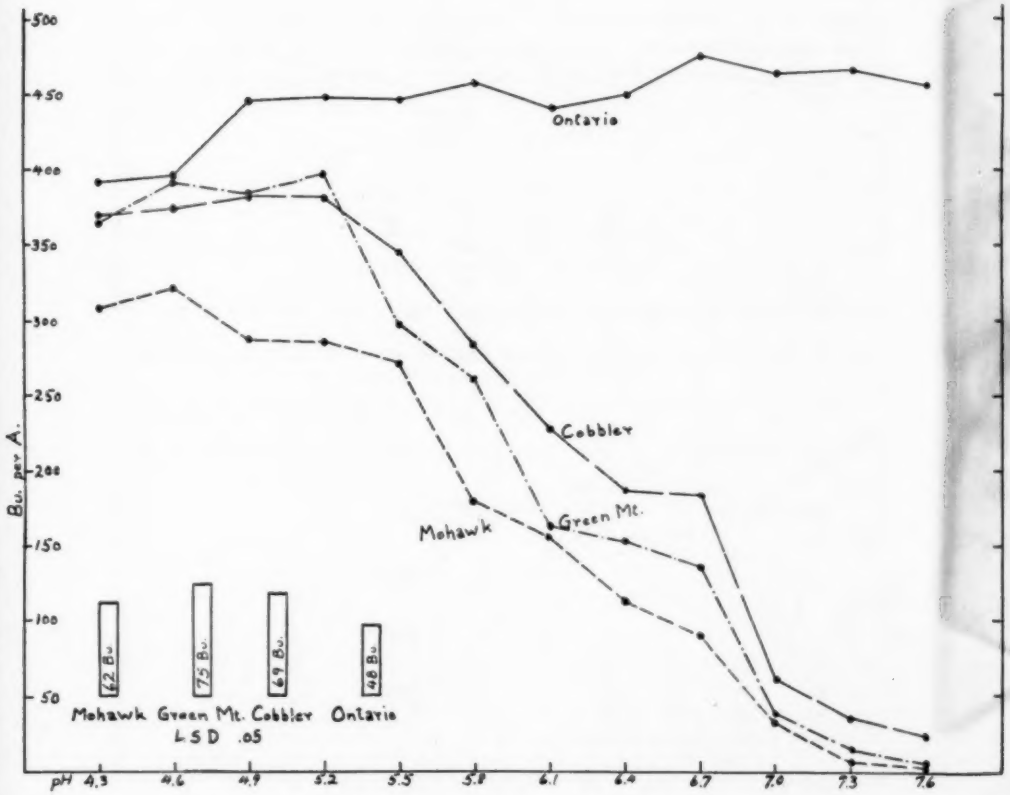

Fig. 1. Effect of soil reaction on yield of U. S. 1 scab-free tubers in 1947.

1948: Results in 1948 were similar to 1947 in that the three susceptible varieties, Green Mountain, Irish Cobbler and Katahdin, produced the highest yield of clean tubers between pH 4.3 and 5.5 (Figure 3). These varieties yielded progressively less scab-free tubers as the pH increased above 5.5. Ontario performed somewhat differently than in the previous year by yielding less at pH 7.6 than at 6.7. This reduction at the high end of the pH scale was not due to scab infection, as can be seen by comparing the Ontario curves in figures 3 and 4.

Total yield, clean plus scabby tubers, is presented in figure 4. All varieties seemed to yield slightly less at pH 7.3 and 7.6 than at lower pH levels.

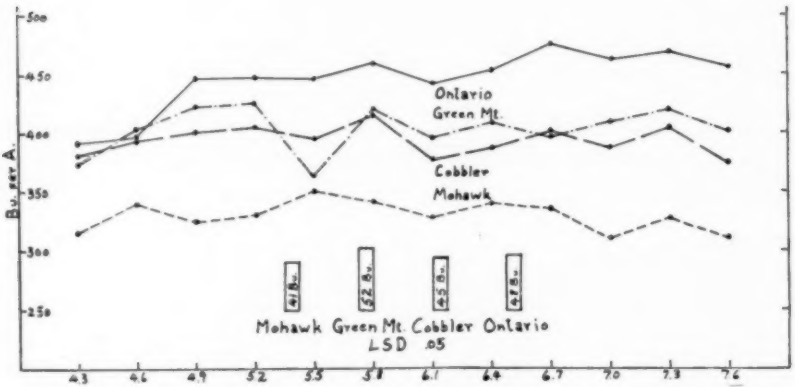

Fig. 2. Effect of soil reaction on total yield of U. S. 1 size tubers in 1947.

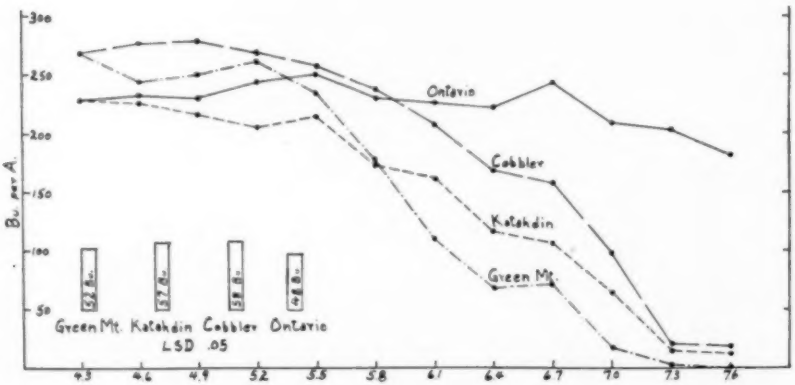

Fig. 3. Effect of soil reaction on yield of U. S. 1 scab-free tubers in 1948.

1949 and 1950: No sorting for scab was done in 1949 or 1950, since Ontario and Yampa both proved so highly scab-resistant as to have only insignificant amounts of infected tubers. Scab lesions on these varieties were always slight.

Ontario was planted alone on the soil reaction plots in 1949, and unfavorable growing conditions were responsible for low yields on all of the plots (Figure 5). The hot dry season that year caused Ontario to sprout profusely in the field, setting chains of small tubers on the apical sprout of the original tuber. Although there were no outstanding differences in yield, there was a slight trend toward higher yields with increasing pH, reaching a peak at 7.3 and declining again at pH 7.6 (Figure 5). The yield at pH 7.3 was statistically higher than yields at 4.3, 4.6 and 5.2.

Yampa and Ontario were grown on the soil reaction plots in 1950. A favorable season produced yields four times as large as the 1949 crop (Figure 5). Ontario yielded best at a pH of 6.4 to 6.7, falling off sharply on the higher pH plots and also yielding less on the most acid plots. Yampa showed no significant difference in yield from pH 4.3 to 7.3, but produced markedly less at 7.6.

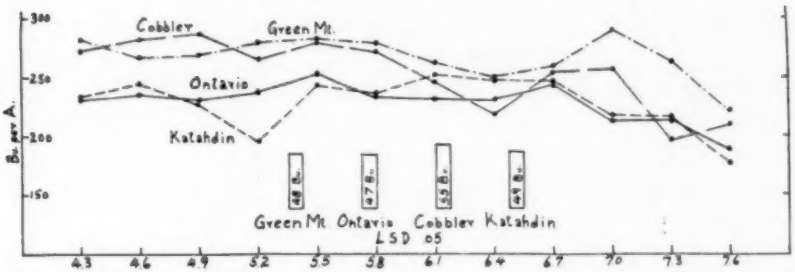

Fig. 4. Effect of soil reaction on total yield of U. S. 1 size tubers in 1948.

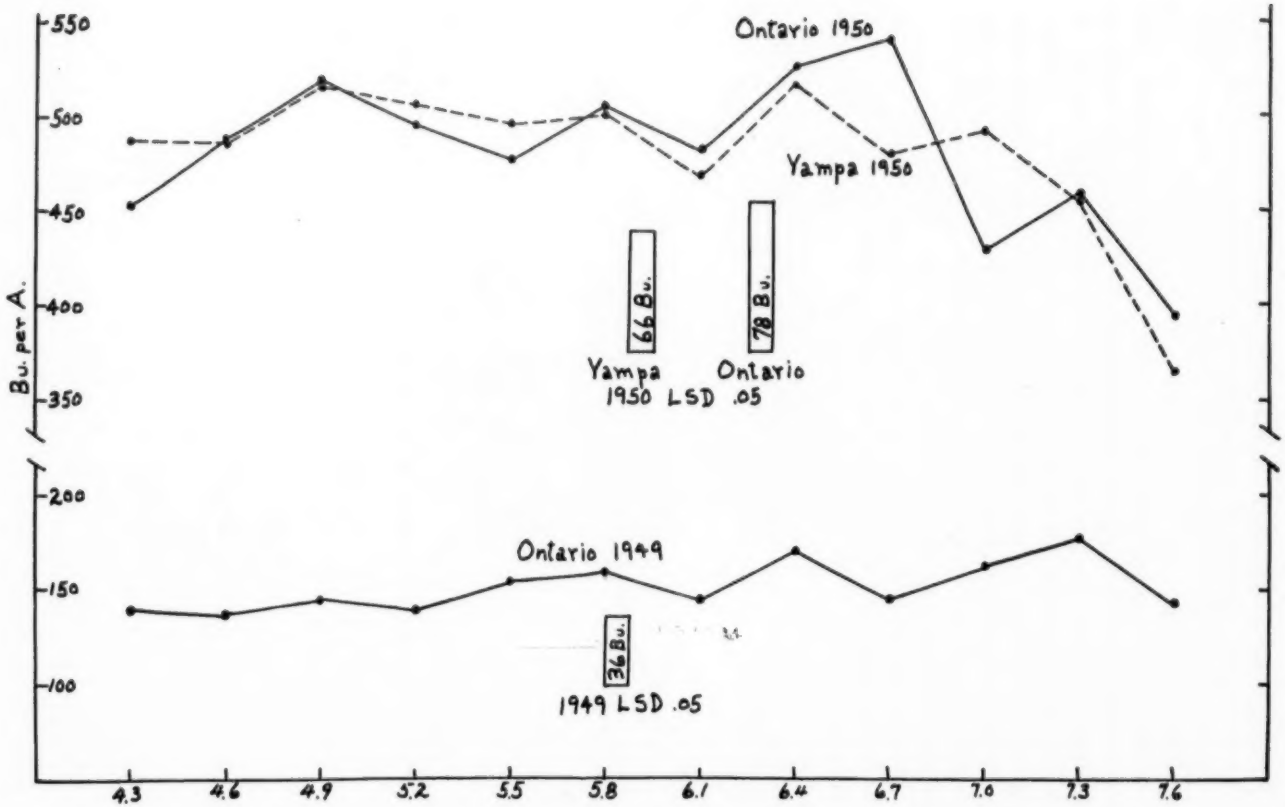

Fig. 5. Effect of soil reaction on yield of U. S. 1 tubers of Ontario in 1949 and of Ontario and Yampa in 1950.

Summary

1. Certain scab-resistant and susceptible potato varieties were grown on permanent plots ranging in pH from 4.3 to 7.6. Four years' results were presented.
2. Green Mountain, Irish Cobbler, Katahdin and Mohawk showed approximately the same susceptibility to scab producing the largest yields of scab-free tubers between pH 4.3 and 5.2, and yielding progressively less clean tubers as the pH increased.
3. Ontario was grown on the scab plots all four years of the study and proved to be highly resistant to scab infection over the entire pH range tested, namely 4.3 to 7.6.
4. Yampa was tested only in 1950. This variety proved to be quite resistant to scab infection over the pH range of 4.3 to 7.6. Yampa yielded well at all pH levels except 7.6, at which point the yield declined significantly.

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AMERICAN POTATO YEARBOOK

The 1951 edition of the AMERICAN POTATO YEARBOOK has recently been published. It is again edited by John C. Campbell, Rutgers University College of Agriculture, and contains 80 pages of vital information to the potato grower, shipper, dealer and all those with an interest in the potato industry.

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The new volume also contains much statistical information of value. There are tabulations by states of both seed and table stock production as well as statistics on Canadian and world potato production.

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